早稲田大学大学院理工学研究科

博 士 論 文 概 要

論 文 題 目

MEDICAL IMAGE PROCESSING
- Compression and Support System for Diagnosis
on The Basis of Fuzzy Set Theory -

医 用 画 像 処 理
－ 圧縮手法およびファジー論理を用いた
診断支援解析手法 －

申 請 者

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PURPOSE OF THIS PAPER

In this research we introduced two methods for medical image compression, the aim of which was to save the computer memory usage and also decrease in the transmission time. In addition we proposed a method which could automatically analyze and diagnose the ischemic heart disease using the Thallium SPECT (Single Photon Computed Tomography) images.

STATUS OF THIS PAPER IN THE CURRENT STATE OF RESEARCH

In most irreversible compression methods, higher compression ratio results in more degradation in all areas of the reconstructed image. The preprocessing routines that we offered allowed the controlable distortion in different areas of the reconstructed image. In addition, we offered a preprocessing routine for error-free compression methods which creates a set of optimum symbols to which a code-word could be assigned. The code-words offered by several coding methods including the Haffman coding were assigned to these optimum symbols. As a result the compression ratio obtained was higher than that of Haffman coding using its own set of symbols.

Unlike the existing Thallium SPECT image analysis methods, our method is completely automatic and it takes full usage of all information available in the SPECT images on pixel basis. The analysis was done on the basis of fuzzy set theory which provided us with comprehensive information about the condition of the left ventricle at exercise and delayed stages.

Brief Summary, Chapter one: MEDICAL IMAGE COMPRESSION

Depending on the purpose for which a medical image is taken, some areas of it (i.e. Region Of Interest, ROI) contain more clinical information than others. The area outside ROI is either the background or contains some clinical information with relative importance. In this chapter we introduced two preprocessing, compression and reconstruction routines.

Preprocessing Algorithm-1 is used for X-ray images. This algorithm creates a threshold matrix which is the same size of the original image matrix. The original image is altered according to this threshold matrix. Then the altered image is passed to the Compression Method-1 which is an error-free compression routine. For X-ray images which are altered according to their threshold matrix, the area inside ROI can be reconstructed identically but those outside it may be reconstructed with controllable amount of deterioration.

Preprocessing Algorithm-2 is used for images which have an omissible background like CT, MR (Magnetic Resonance), radionuclide, ... images. This algorithm automatically extracts the ROI and deletes the background area. Only the ROI is compressed by Compression Method-2 which is an error-free compression routine. In reconstruction step, the background is replaced by an optional gray level and the ROI is replaced to its original location.

These methods were tested on a variety of medical images. The performance of our compression methods were almost the same or better than that of the well known Haffman coding.

Chapter Two: SUPPORT SYSTEM FOR DIAGNOSIS ON THE BASIS OF FUZZY SET THEORY

Using the fuzzy set theory, a method was developed for analyzing the extent and severity of ischemia by comparing the exercise and delayed SPECT images with Thallium-201. The LV (Left Ventricle) was divided into 10 short axial images (slices), at exercise and delayed stages.

A fuzzy set was defined for the myocardium according which a DPM (Defect Probability Matrix) was created for each slice of exercise and delayed stages. It represents the severity of ischemia in pixels of the myocardium. Each slice was divided into 8 equi-angle sectors, and also the LV was divided into 8 equi-angle vertical sectors from apex to base. Using DPMs, the defect probability were calculated for each slice, sectors of each slice and the vertical sectors of LV.

The results were displayed on a CRT by means of images, curves, histograms and a set of numerical values. They showed what percentage of the area of each slice and that of the lateral, anterior, septum and inferior portions have how much defect. They provide comprehensive and easily understood information about the condition of the LV in exercise and delayed stages. Stress induced and persistent ischemia can be diagnosed by visual comparison of patient's curves and histograms with their corresponding normal limits.

The only required input to our method is the file name of the short axial images. The rest of calculations are carried out automatically.